Level 9
99 Gawler Place
Adelaide SA 5000
Postal Address
GPO Box 2010
Adelaide SA 5001
T 1300 858 724
F 08 8410 8545

30 June 2015

Senator John Madigan
Chair
Senate Select Committee on Wind Turbines
PO Box 6100
Parliament House
Canberra ACT 2600

By email: windturbines.sen@aph.gov.au

Invitation to make a written submission: Australian Energy Market Operator

Thank you for your letter dated 2 June 2015 to Mr Matt Zema, Chief Executive Officer and Managing Director of the Australian Energy Market Operator (AEMO). In that letter you sought evidence from AEMO on various matters that have been raised during the inquiry concerning AEMO's roles and responsibilities. These are addressed in turn in the attachment.

AEMO operates the National Electricity Market (NEM), the Victorian Declared Wholesale Gas Market (DWGM) in Victoria, Short Term Trading Markets (STTM) for gas at hubs in Adelaide, Sydney and Brisbane and the gas supply hub at Wallumbilla. AEMO is also responsible for the procurement and planning of the shared network and connections of electricity transmission in Victoria and has a range of national planning functions for electricity and gas transmission.

AEMO does not participate nor invest in any market itself, but its role in supporting Australian energy markets in a technology-neutral manner provides perspectives that are relevant to aspects of your inquiry.

AEMO's expertise is in the operation of energy markets, in particular the management of system security and the integration of various technologies into the Grid. AEMO assesses the electrical characteristics of large generators that seek to connect to the NEM, including wind generators, but has no role in granting or assessing compliance with land-use and environmental approvals.

If you would like to further discuss any matters raised in this submission, please contact me

Yours sincerely

David Swift
Executive General Manager Corporate Development

Attachments: Submission to Senate Select Committee on Wind Turbines

Submission to Senate Select Committee on Wind Turbines

1. Role of AEMO

AEMO is an independent, member based organisation (60 per cent government, 40 per cent industry owned) working in the long-term interests of Australian consumers by ensuring that energy markets operate to balance issues of price, quality, safety, reliability and security of energy supply.

AEMO also delivers an array of gas and electricity market operational and planning functions. It operates in eastern and south-eastern Australia, but not in Western Australia or the Northern Territory.

AEMO does not invest or participate in the markets, but its responsibilities include:

- Day to day management of wholesale and retail energy market operations and emergency management protocols.
- Ongoing market development required to incorporate new rules, infrastructure and participants.
- Long term planning including demand forecasting, scenario analysis and network planning.

1.1. Markets

AEMO operates the retail and wholesale energy markets of eastern and south eastern Australia, including:

- National Electricity Market (NEM)
- Victorian Declared Wholesale Gas Market (DWGM)
- Short Term Trading Market (STTM) – wholesale gas in NSW, SA and Qld

1.2. Operations

AEMO oversees the vital system operations and security of the NEM and the Victorian gas transmission network and the registration of large generators under the National Electricity Rules. This provides it with technical insight into the growth of renewable generation forms, particularly with respect to their asynchronous and intermittent characteristics.

1.3. Planning

AEMO produces a range of planning information documents to assist industry investors and customers[1]. In particular AEMO's annual National Electricity Forecasting Report (NEFR) has become the industry benchmark and now incorporates recent structural shifts in the use of electricity.

The annual National Transmission Network Development Plan (NTNDP) is published in December. This process requires modelling the types and locations of generation investment (or disinvestment) expected in response to various market incentives, including the Renewable Energy Target (RET).

[1] AEMO's planning reports can be found at http://www.aemo.com.au/Electricity/Planning and http://www.aemo.com.au/Gas/Planning

1.4. AEMO's role in the Victorian Electricity Transmission Network

Whilst the assets are physically owned by others (including AusNet Services), AEMO is responsible for planning and procuring all electricity transmission services in Victoria. As part of this role, AEMO arranges transmission network connection projects in Victoria, which gives it detailed experience in the challenges of connecting new generation technologies to the grid.

1.5. Distinction between "Security" and "Reliability"

There is often confusion regarding these terms. This submission uses them in their National Electricity Rules meaning, which are:

- *Security* is the integrity of the overall power system to cope with unexpected, sudden and credible disturbances. If these can occur without plant damage or significant disruption, the power system is considered secure.
- *Reliability* is the adequacy of installed generation supply to meet demand, particularly peak demand. The NEM uses a probabilistic measure of reliability, or reliability standard which targets 99.998% of all customer demand to be supplied at the wholesale level.

AEMO is responsible for monitoring both, and has some powers to act to restore them where necessary.

2. General comments

2.1. Wind generation and electricity network security

There are two key characteristics of wind generation technology that is important to its integration into the electricity grid and market:

- The generation is *intermittent,* in that its output varies as determined by the wind conditions at the time.
- The generators employed are *asynchronous* meaning that, unlike traditional generators, they do not spin in synchronism with the power system. This means that their behaviour during short-term system disturbances is technically different, with complex effects on power system security.

These characteristics also apply to solar photo-voltaic generation, which is a similarly growing supply source to the National Electricity Market.

Concerns are often raised about adverse implications for maintaining electricity system security in power systems with high levels of renewable generation. This is particularly true for renewable generation in South Australia and Tasmania where it has become significant relative to conventional generation. Large volumes of asynchronous and intermittent generation present the following challenges to a traditional power system:

- Intermittency in terms of meeting peak demand. Traditional generation can be relied upon to participate at times of system need with a low, albeit material, failure rate which can be managed with moderate levels of reserve generation. In the case of wind and solar a probability of contribution at time of peak must be developed. For wind this is generally well below their average output over time.
- The potential for variations in outputs, especially occasional large swings or swings that occur with little notice. Other plant, or demand-side management, must be available to respond to these variations.
- The asynchronous generators usually used by these technologies mean that they generally do not contribute to stabilising power system frequency.

As part of AEMO's responsibilities for system security, AEMO has studied and published various reports on the issue[2].

Whilst there are technical challenges, AEMO feels the NEM design is well placed to deal with them. This includes some existing beneficial features, such as:

- Five-minute security constrained, economic dispatch and pricing.
- A relatively high spot market price cap of $13,500 per Megawatt hour which strongly rewards supply when it is needed to meet demand. This is supplemented by a negative price floor of minus $1,000 per Megawatt hour which strongly encourages generation, including wind, to reduce output when supply exceeds demand.
- The Australian Wind Energy Forecasting System (AWEFS) which is forecasting output well and thereby assisting non-intermittent plant to predict dispatch. This system has been expanded to forecast the output of large solar plants.
- The semi-scheduled generator provisions in the National Electricity Rules (NER) that oblige intermittent generators such as wind generators to respond to AEMO dispatch signals to reduce output to manage network security.

The NEM has been uniquely successful in securely integrating wind generation to date at low cost. For example, AEMO has not had to change or materially increase the quantity of ancillary services purchased to maintain system security.

South Australia demonstrates the success of the NEM in integrating wind generation, given that it has one of the world's highest wind penetrations. Wind generation there contributes 35% of regional grid-connected output on average and on occasion its output has exceeded the entire local demand (excluding exports to Victoria)[3]. While wind generation in South Australia is being well managed operationally by the market, the market prices obtained reflect the high concentration of wind generation which is not correlated to demand. Other things being equal, investment in wind generation in regions with lower existing penetration therefore becomes relatively more attractive, implying that future investment will be more evenly spread.

However challenges may still arise in the future, especially if wind generation becomes even more concentrated, or in combination with larger amounts of photovoltaic generation. In that regard, AEMO is continuing to study the issues will release further reports from time to time.

Based on experience to date and analysis of likely future outcomes, AEMO considers that it is technically feasible to integrate the renewable energy likely to emerge from the RET while maintaining the security of the power system. In the longer term if even higher levels of renewable generation eventuate, there is likely to be some additional grid support costs to maintain system security and to meet frequency standards.

2.2. Wind generation impact on transmission costs

Under the NEM rules, where any new generator, including a windfarm, requires an extension from the existing shared network to connect, it is that generator's responsibility to negotiate requirements with the relevant network owner and fund that extension. Connection costs are therefore part of any new generators construction cost.

In contrast, the shared transmission network is centrally planned and funded by customers. This central planning process takes account of any load growth and the changing

[2] These can be found http://www.aemo.com.au/Electricity/Planning/Integrating-Renewable-Energy, http://www.aemo.com.au/Electricity/Planning/South-Australian-Advisory-Functions/South-Australian-Wind-Study-Report and http://aemo.com.au/Electricity/Planning/Related-Information/Wind-Integration-Investigation

[3] http://www.aemo.com.au/Electricity/Planning/South-Australian-Advisory-Functions/Wind-Study-Report

requirements of customers and focusses on maintaining reliability of supply to customers. Supply to customers is affected by the location and form of generation and this may indirectly affect the cost of the shared transmission system. Additional investment in transmission may be justified where that investment lowers overall costs; that is, it delivers a net market benefit.

However attempting to attribute additional shared transmission costs resulting from the RET is challenging. For example AEMO and ElectraNet are currently arranging an expansion of the Victorian to South Australian interconnection[4]. The economic studies that demonstrated the expansion would deliver net market benefits took account of growing wind generation, and the network congestion that would otherwise occur in South Australia on windy days. However it also includes other benefits from the expansion, such as providing additional reliability to South Australia on non-windy days.

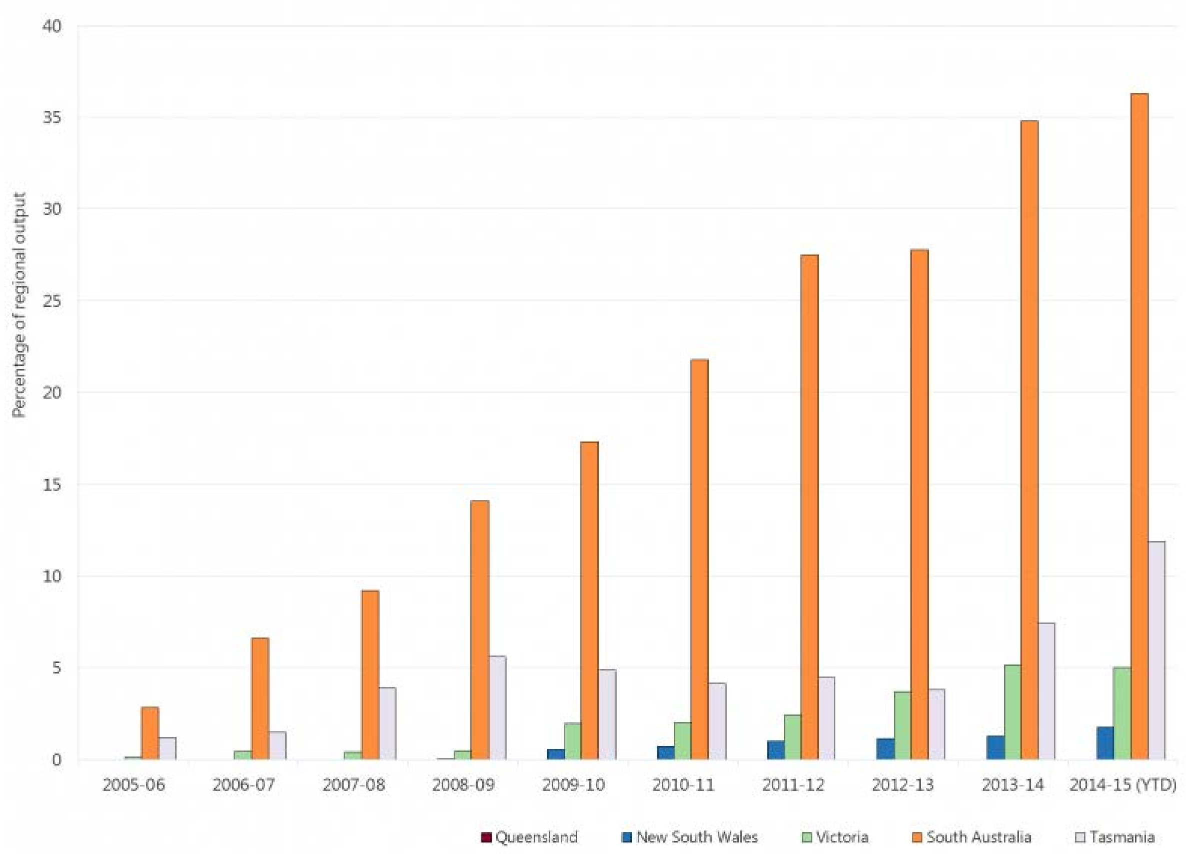
3. Responses to Questions

3.1. Question 1

Recent data and analysis that AEMO has gathered and conducted on the contribution that wind energy makes to the National Electricity Market.

In the 2014-15 year to 1 April, wind generated 4.7% of grid-connected NEM generation supply. As seen by the figure below, wind energy has been growing rapidly, and is most concentrated in the South Australian region of the NEM.

Figure 1: Wind output as a percentage of regional output



Source: AER "State of the Energy Market' derived from AEMO data.

[4] See http://www.aemo.com.au/Electricity/Planning/Regulatory-Investment-Tests-for-Transmission/Heywood-Interconnector-RIT-T

3.2. Question 2

AEMO's view of the accuracy and reliability of analysis using AEMO's five minute data (see submission 91 to the inquiry by Mr Peter Bobroff and the following site developed and maintained by RenewEconomy.com.au).

AEMO has reviewed this submission and a related blog[5]. We have not attempted to verify Mr Bobroff's analysis, however the figures and quantities appear reasonable and broadly consistent with our own reports[6].

AEMO cannot comment on the conclusions Mr Bobroff has drawn from that analysis. We urge caution regarding the following statements:

> *Gas and hydro provide the peak loads with their reliable quick responses. Sometimes only a little peaking is required, but their rapid responsive reserve is always needed for overall grid reliability.*

Whilst gas and hydro generation are generally very flexible technologies, all other forms of generation also have flexibilities to various degrees. It is incorrect to suggest these generators are always needed or that these characteristics are entirely absent from other technologies. The NEM operates to utilise the full capability of all generation available to the market nationally at a particular point in time.

> *However four times more frequently, they had to draw power from the grid to prevent damage to their main bearings during calms.*

Whilst windfarms occasionally draw power from the grid, the actual quantities are very small, in the order of 1% of rated output and of brief durations, typically a few hours only.

> *With their special status and extremely low marginal costs, there seems little to prevent wind companies undercutting themselves in a downward spiral.*

It is unclear what "special status" Mr Bobroff is referring to. AEMO dispatches generators according to their offers (or bids) in a technology neutral manner. Most wind generators are registered as "semi-scheduled generators" which dispatches them on the same terms as traditional generators and obliges them to reduce output when necessary to manage network congestion. The comment may be confused by some overseas markets where wind generators have a "must-run" status.

With respect to Mr Bobroff's expressed surprise that NEM prices can become negative, AEMO notes that this is an intentional and desirable feature of the market, having existed from the start of the NEM in 1998. Negative 5 minute spot market prices are necessary to deal with short-term surpluses and have proven very effective in balancing the system during high wind-low demand periods. Even without wind generation, surpluses can occur during short periods of very low demand, when traditional generators reach their minimum stable output, and require a strong incentive to justify a shutdown and restart cycle.

The site developed and maintained by RenewEconomy.com.au draws data from the NEMWatch tool produced by Global-Roam Pty Ltd. Global-Roam is a well-known and reputable firm specialising in repackaging AEMO data into readily accessible formats. AEMO has not audited the site and is not aware of the detailed definition of data displayed. However the data appears reasonable and we have no reason to question the veracity of the Global-Roam product.

---

[5] https://pubknowaust.wordpress.com/

[6] See in particular http://www.aemo.com.au/Electricity/Planning/South-Australian-Advisory-Functions/South-Australian-Wind-Study-Report

3.3. Question 3

An overview of the latest AEMO analysis of the levelised cost of electricity for each energy source and the trends over time.

AEMO is not an investor itself but for its planning functions it obtains expert advice with respect to new entrant cost. Information can be found in AEMO's planning assumption pages[7]. In particular our 2014 fuel and technology cost review may be of value[8]. We also include specific information on South Australian technology costs as part of our South Australian advisory functions[9].

The following two tables provide the levelised cost of energy (LCOE) for generation options presented in the 2015 South Australian Fuel and Technology report.

Table 12 LCOE and emissions comparison across technologies (renewables)

Technology	Fuel type	Max Capacity factor (%)	2014		2015	
			CO_2 emissions ($kgCO_2$-e/MWh)	Minimum LCOE ($/MWh sent out)	CO_2 emissions ($kgCO_2$-e/MWh)	Minimum LCOE ($/MWh sent out)
Wind (100 MW)	Wind	43	-	99	-	99
Biomass	Biomass	70	23	100	23	119
Solar PV (FFP)	Solar	21	-	224	-	149
Solar PV (SAT)	Solar	21			-	183
Solar PV (DAT)	Solar	21			-	240
Solar thermal (CR with storage)	Solar	42	-	277	-	218
Solar thermal (CLF)	Solar	23	-	328	-	284
Solar thermal (PT with storage)	Solar	42	-	302	-	294
Wave[157]	Oceanic	60			-	147
Geothermal - HAS	Geothermal	83	-	137		
Geothermal - EGS	Geothermal	83	-	137		

[7] http://www.aemo.com.au/Electricity/Planning/Related-Information/Planning-Assumptions
[8] See report http://www.aemo.com.au/Electricity/Planning/Related-Information/~/media/Files/Other/planning/2014%20Assumptions/Fuel_and_Technology_Cost_Review_Report_ACIL_Allen.ashx and data http://www.aemo.com.au/Electricity/Planning/Related-Information/~/media/Files/Other/planning/2014%20Assumptions/Fuel_and_Technology_Cost_Review_Data_ACIL_Allen.ashx
[9] http://www.aemo.com.au/Electricity/Planning/South-Australian-Advisory-Functions/South-Australian-Fuel-and-Technology-Report

Table 13 LCOE and emissions comparison across technologies (non-renewable)

Technology	Fuel type	Capacity factor (%)	Region	2014		2015	
				CO2 emissions (kgCO2-e/MWh)	Minimum LCOE ($/MWh sent out)	CO2 emissions (kgCO2-e/MWh)	Minimum LCOE ($/MWh sent out)
Open Cycle (OCGT)	Gas	10	SA	700	240	699	205
			NEM	700	240	592	195
Combined cycle (CCGT)	Gas	83	SA	499	101	478	82
			NEM	499	101	405	73
Combined cycle (CCGT – with CCS)	Gas	83	SA	213	140		
			NEM	213	140	97	115
Supercritical (SCPC)	Brown coal	83	SA				
			NEM			1213	91
Supercritical (SCPC – with CCS)	Brown coal	83	SA				
			NEM			175	169
Supercritical (SCPC)	Black coal	83	SA				
			NEM			827	72
Supercritical (SCPC – with CCS)	Black coal	83	SA				
			NEM	123	152	134	140
Supercritical (SCPC – with oxy combustion CCS)	Black coal	83	SA				
			NEM	22	158		
Integrated Gasification and Combined Cycle (IGCC – with CSS)	Black coal	83	SA				
			NEM	150	191		
Integrated solar combined cycle (ISCC)	Gas / Solar	83	SA	446	123	450	103
			NEM	376	112	440	92

Note that costs in this able include both the technology costs and the cost of fuels over the life of the plant. These then incorporate forecasts of the future costs of the relevant fossil fuel.

3.4. Question 4

How the 'merit order effect' operates in Australia and whether international regulators employ the same system.

How frequently does electricity from renewables (and wind in particular) 'push out' electricity generated from thermal sources? Does AEMO publish research on this issue?

The “merit order effect” is a colloquial term, which, as we understand it, describes how subsidised new supply lowers the wholesale price of electricity by adding low short run cost generation to the total supply stack or merit order. In the case of renewable generation, the low offer price and resulting lower spot market price is only possible because that generation has alternative sources of funding. In this case, any lower price paid to other generators represents a “wealth transfer” from producers to consumers, but does not change overall net societal costs.

Markets in some other jurisdictions are also subject to this effect when new supply receives subsidies on top of market returns. The issue is frequently discussed in relation to Germany, albeit with different terminology.

We are aware that some commentators have on occasion analysed AEMO’s data on individual days and postulated wholesale prices would have been higher had renewable energy not been operating. Such analyses should be treated with caution, as they do not consider the complex long-term feedback loops that exist in the real market. For example, when wholesale prices are suppressed for a period of time, non-subsidised plant is likely to withdraw. This in turn has the effect of bringing wholesale prices back up to a new equilibrium over time.

In our submission to the 2014 Warburton Review of the Renewable Energy Target, AEMO discouraged the panel from placing weight on these wealth transfers:

> *Cost Benefit Analysis (CBA) studies are standard practice in the industry. They are undertaken for all changes to market rules and procedures and for justifying shared network augmentations.*
>
> *The CBA approach nets all costs and benefits across all producers and consumers to determine the "net market benefit". Within the overall net market benefit there will be a range of benefits and dis-benefits to individuals and sectors of the market. Whilst allocative insights can be useful, the prime decision tool should remain an assessment of the overall net market benefit. Such an approach is consistent with the National Electricity Market Objective's focus on the long-term interests of consumers because:*
>
> - *Presuming the market design and structure permits workable competition and new entry, cost burdens or savings experienced by producers will, in time, be ultimately passed on to consumers.*
> - *Whereas net market impacts can be reasonably estimated, the forecasting of prices is difficult as it requires predicting producer pricing behaviours and second-order effects, such as new investments, producer withdrawals, mergers and divestments. In AEMO's experience, assessing consumer price impacts of policy change are highly dependent on the modelling assumptions and approach used, and should not be relied upon by policy makers.*

The Australian Energy Market Commission's submission to that review discussed this matter in some depth[10].

AEMO has not publish any data or research on the extent to which renewables (and wind in particular) have 'push out' other generation. It can be reasonably assumed that all renewable output in the NEM substitutes for non-renewable output.

3.5. Question 5

> *AEMO's view on whether the rising proportion of electricity generation from wind in recent years has aided or abetted this objective of system security and supply reliability.*

See earlier discussion in section 2.1.

3.6. Question 6

> *AEMO's view of the claim made by one submitter that the geographically large and highly dispersed nature of Australia's wind farm fleet poses 'significant security and reliability concerns to the eastern Australian grid'*

We understand this is a quote from the extract of a paper by Mr Paul Miskelly published in the Energy & Environment journal, Vol. 23, No. 8, 2012.

The paper's supporting data demonstrating wind generation variability has been drawn from AEMO data and is largely consistent with AEMO's publications[11].

---

[10] https://retreview.dpmc.gov.au/sites/default/files/webform/submissions/AEMC%20submission%20-%20RET%20Review%202014_signed_FINAL_0.PDF

Taken by itself, the inference that geographic diversity of wind generation raises security and reliability concerns is incorrect. Rather the broad geographical spread of wind generation in South East Australia reduces aggregate variability and lessens security and reliability concerns. However as noted in the paper, South East Australia does have occasional very widespread high and low wind patterns, including calms that can affect every large NEM windfarm simultaneously.

Whilst this creates challenges for the NEM, AEMO would not say that it poses "significant security and reliability concerns". AEMO is responsible for overseeing reliability (adequacy of generation to meet demand) and system security (the grid's ability to withstand credible disturbances) and carefully analyses the technical challenges of integrating the current and future levels of renewable energy. When issues arise or are anticipated, AEMO has mechanisms through which they can be addressed.

With respect to claims made in the paper, AEMO notes:

- Single generating units *are* deemed credible contingency events in the NEM as they are in other power systems (Pg. 1243). The "Reviewable Operating Incidents" list does not include these events.
- Large traditional generators set the NEM's contingency requirements based on the risk that they can trip under load. An individual wind turbine tripping is inconsequential and wind farm generation variability occurs over a longer timescale. (Pg 1243, 1248).
- Contingency requirements relate to maintaining system security. This is unrelated to Minimum Reserve Levels which are used for assessing reliability (Pg 1246).
- The upgrade to the Victoria – South Australia interconnector presently under construction does not involve new lines (Pg 1249). It involves installation of one new 500 to 275 kilovolt transformer, a series compensator and associated minor works at a total project cost estimated at $108 million[12] not "several billion $AUD". The upgrade was justified on net market benefits, including reliability benefits for South Australian customers at time of peak demand. It is incorrect to say it is "for the sole purpose of balancing the effects of wind's volatility" nor was this stated or implied by Swift 2009 or Swift 2010.
- The claim of $AUD4–10 billion for "transmission augmentations required to deal with this increasing wind penetration" is incorrect. The Chapman 2011 references were to the forecast total transmission investment over the 20 year outlook period. At that time planning was based on high demand growth forecasts. Since that time demand growth has reduced substantially and forecast transmission spending is now much lower. The Chapman 2011 references include no mention of wind generation. See above section 2.2 for discussion on transmission costs.
- In page 1251 Miskelly suggests the variability of the entire NEM's wind fleet creates a greater common-mode failure risk than the loss of the largest NEM traditional generator unit of (750 MW). The two risks should not be compared in this manner. The largest generator can fail instantaneously, whereas a decline in widespread wind output occurs over an extended period. As the dispatch engine iterates to correct supply/demand variations every five-minutes, the key risk is created by how much total generation can vary within this time period. AEMO's historical assessments

[11] See in particular See in particular http://www.aemo.com.au/Electricity/Planning/South-Australian-Advisory-Functions/South-Australian-Wind-Study-Report
[12] Material on the upgrade can be found here: http://www.aemo.com.au/Electricity/Planning/South-Australian-Advisory-Functions/Heywood-Interconnector-Update

show that total wind output varies considerably less than 750 MW in a five-minute period[13].

- In page 1252 Miskelly correctly notes that AEMO only counts a small percentage of wind generation capacity as reliable to meet peak demand in reliability forecasts[14]. This means that installation of wind generation capacity only slightly offsets the need for other generation to meet the reliability standard. This should not be interpreted to mean that reliability is necessarily threatened by it. The market is designed to reward generation as required to meet demand, with the high market price cap intentionally selected to provide sufficient income to reward non-intermittent plant that may operate only very occasionally.
- In page 1252 Miskelly describes the formation of wind clusters. AEMO has recently focused its wind assessments for planning purposes on these clusters.

3.7. Question 7

AEMO's view on the benefits that arise where the power system's spinning reserve increases.

The NEM does not employ the North American term "spinning reserve", and, due to differences in market design, is not directly comparable to any feature of the NEM.

AEMO operates "Frequency Control Ancillary Services" (FCAS) markets which match supply and demand over timescales shorter than the NEM's energy dispatch cycle of five minutes[15]. Beyond that timescale variations are balanced by energy dispatch. In some overseas markets the dispatch cycle is longer, e.g. 60 minutes, requiring balancing services beyond the scope of FCAS. Some energy markets operate on a day ahead basis rather than in real time. These characteristics make the question difficult to interpret and answer.

AEMO recruits sufficient FCAS in order to meet the frequency standards and keep the power system secure at all times. To date AEMO has not measurably changed the amount of FCAS it recruits as a result of the growth in wind generation. It is possible that more of one form of FCAS – regulation – may be required in time due to the sub five-minute variability of wind generation. It should be noted that total NEM FCAS costs are relatively small, comprising about one percent of energy market turnover.

3.8. Question 8

The Clean Energy Regulator notes in its submission (number 93) that 'all new wind farms that AEMO is aware of are proposing to use either type 3 or type 4 wind turbines'. What the particular benefits of this technology and how is AEMO made aware of information about technology that will be used in future developments?

AEMO has a role in the connection of all new generation to the national grid. All generators are assessed against the requirements in the Rules and the technical standards to which they are to adhere are determined. During this process we undertake modelling (or review modelling undertaken by others) and through this gain insights into the technology and performance of each new windfarm. This data is important to maintain the Australian Wind Energy Forecasting System (AWEFS), monitor system performance and undertake forward planning.

[13] South Australian variations are shown in table 8, 14 figure 11 of http://www.aemo.com.au/Electricity/Planning/South-Australian-Advisory-Functions/~/media/Files/Other/planning/SAWR%202014/2014_South_Australian_Wind_Study_Report_v2.ashx . NEM-wide variations are proportionally smaller.
[14] Ibid, table 5.
[15] See http://www.aemo.com.au/Electricity/Market-Operations/Ancillary-Services

There is no requirement to employ a given technology. The technical requirements in the rules are technology neutral and set the level required to meet the system standards for power quality and system security. Given a windfarm must meet these standards at the same time as maximising its performance, proponents are generally driven to using leading technologies. In windfarms this is seen by the use of type 3 and type 4 turbines.

The technical characteristics of these turbines are easier to incorporate into the grid than their predecessors. However they do not contribute inertia in the same manner as traditional generation, and AEMO is presently studying the implications of this matter.

3.9. Question 9

An overview of the forecasting work that AEMO conducts, with particular reference to:

- *the factors that affect AEMO's forecasting of the future supply of renewables, and wind in particular; and*
- *the anticipated surplus supply of electricity in the NEM.*

See section 1.3 above, which contains references to the range of planning reports that AEMO publishes.

AEMO recently published its National Electricity Forecast Report (NEFR) which provides the critical customer demand forecasts that underpin our planning. These forecasts are compared to the available supply as notified to us by market participants and intending participants in the Electricity Statement of Opportunities (ESOO). This year's ESOO will be published by the end of August.

By the end of the year, AEMO will publish the 2015 National Transmission Network Development Plan which will project supply and demand for several scenarios over the next 20 years. The plan will then examine the need for supporting investment in the transmission network to maintain reliable supply.

The NTNDP aims to model the likely investments and dis-investments market participants will make in generation over the outlook period. With respect to wind generation, the key planning factors are:

- The size of the large-generation certificate (LGC) target generation driven by the RET scheme.
- The LGC penalty price, and whether this provides sufficient return to allow investment in generation to be recovered.
- Other large-scale renewable incentives, such as voluntary greenpower and the Australian Capital Territory feed-in tariff scheme.
- The locational economics of various wind locations, including those in Western Australia.
- The wholesale electricity prices achieved by wind in each region.
- The proximity and adequacy of the existing network, and the electrical losses at the connection point.

Wind generation is forecast to dominate new investment in renewable generation that is eligible for LGCs. The principle other expected supply of renewable generation is small-scale photovoltaic generation which participates in the Small-scale Renewable Scheme (SRES) and whose economics is affected by the retail price of electricity rather than wholesale market prices.

The 2014 Electricity Statement of Opportunities (ESOO) indicated that as much as 7,500 MW of capacity could be withdrawn from the NEM, in a specific locational pattern, without falling below the reliability standard[16]. Since that time a number of plants have withdrawn or announced planned withdrawals, and demand forecasts have been increased in the 2015 National Electricity Forecasting Report (NEFR). The 2015 ESOO will therefore reduce this surplus.

AEMO also operates the AWEFS system to assist participants by estimating wind and large-scale solar outputs in the short-term time horizon, discussed above in section 2.1.

16 http://www.aemo.com.au/Electricity/Planning/Electricity-Statement-of-Opportunities